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ABSTRACT

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THE ALPHABETIC PRINCIPLE AND LEARNING TO READ

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by
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Abstract

Proper application of the alphabetic principle rests on an awareness of the internal phonological (and morphophonological) structure of words that the alphabet represents. Unfortunately for the would-be reader-writer, such awareness is not an automatic consequence of speaking a language, because the biological specialization for speech manages the production and perception of these structures below the level of consciousness. Not surprisingly, then, awareness of phonological structures is normally lacking in preliterate children and adults; the degree to which it does exist is the best single predictor of success in learning to read; lack of awareness usually yields to appropriate instruction; and such instruction makes for better readers. That some children have particular difficulty in developing phonological awareness (and in learning to read) is apparently to be attributed to a general deficiency in the phonological component of their natural capacity for language. Thus, these children are also relatively poor in short-term memory for verbal information, in perceiving speech in noise, in producing complex speech patterns, and in finding the words that name objects. All children will benefit from instruction that is intelligently designed to show them what the alphabet is about.

Résumé

L'application juste du principe alphabétique repose sur une intuition de la structure phonologique (et morphophonologique) interne des mots que représente l'alphabet. Quant au prétendu lecteur-écrivain, malheureusement, telle intuition n'est pas une conséquence automatique de parler une langue, parce que la spécialisation biologique pour la parole dirige la production et la perception de ces structures au-dessous du niveau de la conscience. Alors, on n'en est pas surpris que l'intuition des structures phonologiques manque normalement aux illetrés, et les enfants et les adultes. Le point jusqu'auqel elle existe, ça prédit le mieux que l'on réussira à apprendre à lire; le manque de cette intuition cède d'ordinaire à l'enseignement approprié; tel enseignement forme de meilleurs lecteurs. A cause, semble-t-il, d'un défaut général du composant phonologique de leur capacité naturelle de la langue, quelques enfants subissent des difficultés en développant l'intuition phonologique (et en apprenant à lire). Ainsi, ces enfants-là manquent quelque peu de mémoire de courte durée pour les renseignements verbaux, aussi bien que la faculté de percevoir la parole dans le bruit, d'énoncer des expressions complexes, et de trouver des mots qui nomment les objets. Tous les enfants profiteront de l'enseignement formé avec intelligence pour leur montrer de quoi s'agit l'alphabet.

Zusammenfassung

Die richtige Anwendung des alphabetischen Prinzips auf Sprache setzt voraus, daß die interne phonologische (und morphophonologische) Struktur der Wörter bekannt ist. Ungluecklicherweise fur den Schreiben Lesenlernenden ergibt sich die Kenntnis dieser Struktur nicht automatisch aus der Fähigkeit, die Sprache zu sprechen, da die biologische Spezialisierung für Sprache Perception und Produktion dieser Strukturen ohne Einschaltung des Bewußtseins erlaubt. Es ist daher nicht überraschend, daß

Kindern und Erwachsenen vor dem Lesenlernen üblicherweise phonologische Strukturen nicht bewußt sind. Das Ausmaß, wieweit solche Strukturen bewußt sind, ist im Verlauf des Lesenlernens der beste Parameter für die Beurteilung des Lernerfolges. Meist ist es durch einfache Instruktionen möglich, diese Strukturen zu vermitteln, und die Lesefähigkeit kann verbessert werden. Die Tatsache, daß einige Kinder besondere Schwierigkeiten haben, phonologische Strukturen zu erfassen (und demzufolge Lesen zu lernen), muß offenbar einem allgemeinen Defekt in der phonologischen Komponente ihrer natürlichen Sprachkompetenz zugeschrieben werden. So haben diese Kinder ebenfalls Schwächen im Kurzzeitgedächtnis für verbale Informationen, in der Sprachperzeption unter Störeinflüssen, in der Produktion komplexer Sprachmuster und im Benennen von Gegenständen. Von ausnahmslos positivem Effekt für die betroffenen Kinder ist eine Lehrmethode, die in intelligenter Weise die Funktion des Alphabets vermittelt.

Resumen

Una aplicación adecuada del principio alfabético se basa en el conocimiento de la estructura fonológica (y morfofonológica) de las palabras que representa el alfabeto. Desafortunadamente para el lector-escritor potencial, tal conocimiento no es consecuencia automática de la capacidad del habla de una lengua, puesto que la especialización biológica para el habla comporta la producción y percepción de estas estructuras de modo inconsciente. Así pues, no es sorprendente que el conocimiento de las estructuras fonológicas esté ausente normalmente en los niños y en los adultos que todavía no han aprendido a leer ni a escribir; el grado de tal conocimiento es la mejor garantía de éxito en el aprendizaje de la lectura; la ausencia de conocimiento comporta normalmente una instrucción apropiada; y esta instrucción forma mejores lectores. El hecho de que algunos niños muestren una dificultad especial en el desarrollo del conocimiento fonológico (y en el aprendizaje de la lectura) se debe apar-

entemente a una deficiencia general en el componente fonológico de su capacidad natural para el lenguaje. Se da el caso de que estos niños también presentan una actuación bastante deficiente por lo que respecta a la memoria a corto plazo sobre información verbal, a la percepción del habla enmascarada con ruido, a la producción de estructuras complejas del habla, y a la búsqueda de palabras para nombrar objetos. Todos los niños deben beneficiarse de un tipo de instrucción que haya sido planificada inteligentemente para mostrarles en qué consiste el alfabeto.

For some fifteen years, we have been exploring the sources of the problems beginners encounter in learning to read. Since children are quite fluent in their native language when first encountering the language in print, we began by asking what seemed to us the obvious question: what is required of the child in reading a language but not in speaking or listening to it? The first answer that came to mind, of course, was the discrimination of the visual shapes of the letters. But investigators who had done comprehensive studies of many different aspects of the reading process (see Doehring 1968), or who had compiled exhaustive reviews of the visual factors involved in reading (Benton and Pearl 1978; Stanovich 1982; Vellutino 1979; Vernon 1957), were all in agreement that beginners who were making little progress in learning to read generally showed no significant difficulty in the visual identification of letters.

Beyond letter identification, reading requires mastery of a system that maps letter shapes to units of speech. However, as we noted years ago (Liberman 1973), there is no evidence that children of normal intelligence, given proper instruction, have difficulty in associating individual letters of the alphabet with their appropriate speech equivalents. Perhaps, then, they are defeated by the often complex and irregular relations in English between spelling and language. Surely, the complexities of English spelling do create some problems. But even when the items to be read include only those words that map the sound

in a simple, consistent way, many children still fail (Savin 1972).

Learning to identify the letters, learning to associate them with consonant and vowel sounds, learning to cope with the irregularities of English spelling—none of these is the primary obstacle in learning to read. What is it then that makes reading so hard while speech is relatively so easy? In the seventies, we (Liberman 1971; Shankweiler and Liberman 1972) and other investigators (Elkonin 1973; Gleitman and Rozin 1977; Klima 1972; Mattingly 1972) proposed another possible source of difficulty in reading that is not present in speech. Although both reading and speech require some degree of mastery of language, reading requires, in addition, a mastery of the alphabetic principle. This entails an awareness of the internal phonological structure of the words of the language, an awareness that must be more explicit than is ever demanded in the ordinary course of listening and responding to speech. If this is so, it should follow that beginning learners with a weakness in phonological awareness would be at risk.

We here first set forth the considerations that led us to that view, followed by the evidence that supports it. Then we say why we should consider that deficits in awareness of the phonological structure may be only one symptom of a more general underlying deficiency in the phonological component of the beginning reader's capacity for language. Finally we consider the implications for instruction.

Phonology and the Alphabetic Principle

We begin, then, with the assumption that reading by an alphabetic writing system requires mastery of the alphabetic principle. Surprisingly, this assumption, which seems to us a truism, is not accepted by everyone in the field, as we will see. But even among those who think the principle important, many take it—we would say mistake it—to mean simply an understanding by the would-be reader that the discrete letters of the alphabet

represent the discrete sounds of speech. Our view (Liberman 1983) is different. As we see it, the letters of the alphabet do not represent sounds as such, but rather the more remote phonological (and morphophonological) segments those sounds convey. This is not to quibble. For surely it must be somewhat confusing to children to be told that the word *bag* is spelled with three letters, when their ears tell them plainly that it has but one sound. The confusion is only worse confounded if the teacher insists, against the evidence of what the child hears, that *bag* can be divided into three sounds, and that these can then be "blended" so as to re-form the word. For there is, in fact, no way, with or without the marvels of modern technology, to divide *bag* into pieces of sound that correspond in any reasonable way to the sounds of the three letters, nor is there any way to synthesize the word by somehow putting the letter sounds together. Though bag does truly consist of three segments—it differs from *sag* in the first, from *big* in the second, and from *bat* in the third—these segments are to be found only in the underlying phonology, not in the surface appearances of the sound (Liberman et al. 1967).

To emphasize that letters stand for sounds also risks making it that much harder for a reader to understand perfectly reasonable aspects of English spelling—for example, *cats* and *dogs*, instead of *cats* and *dogz*; or *bat* and *batter*, instead of *bat* and *badder*; or *an apple*, instead of *uh napple*; and so on. As for those aspects of English spelling that are most egregiously unreasonable—for example, *through*, *rough*, and the like—we confess that even a proper understanding of the alphabetic principle is not likely to be of much help, but then neither will anything else, short of learning about how the language has changed since the orthography was developed. (Such spellings need not be a hindrance if they are introduced only after the more systematic aspects of the orthography have been understood.)

The identification of letters with sounds promotes yet another misunderstanding, this one about the nature of words and how they are perceived. For it accords all too well with the

commonplace notion that it is only spoken words that are made of phonological units. Words that come to us via print are incorrectly thought to be different, in that they supposedly can (and perhaps should) be perceived independently of phonology. On this basis, some advise that the reader be taught from the very beginning to skip the phonology (read this as skipping the sound) and go "direct to meaning" (Goodman 1976; Smith 1971). Others grant that going through the phonology—which is taken to mean "sounding it out"—may be useful for the beginning reader, or for the mature reader who encounters a strange word, but they otherwise hold that the putatively "direct" (nonphonological) route is the way to go (Coltheart 1978; Waters, Seidenberg and Bruck 1984).

We believe that these assumptions seriously misconstrue the nature of words and the processes by which they are produced and perceived, in print as in speech. Consider, in this connection, a critical difference between language and all other natural forms of communication. In all the nonlinguistic systems—whether the medium is acoustic, optical, electrical, or chemical—meanings are conveyed by signals that differ holistically, one from another. That is to say that there are no words. The inevitable consequence is that the number of meanings that can be communicated is limited to the number of holistically different signals the animal can produce and perceive, a number that is always quite small. Even if that number can somehow be increased, there is no way of doing it so as to guarantee that the new signals will be immediately recognized as belonging naturally to a system that has a specifically communicative function.

Language is different in a most important way. Meanings are not conveyed directly by signals that differ holistically, but rather by words that are distinct from each other in their internal structure. This structure is formed of a small number of meaningless phonological segments we know as consonants and vowels, and governed according to a highly systematic combinatorial scheme called phonology. The consequence is that words can (and do) number in the tens of thousands. Moreover, there

is a perfectly natural basis for accommodating new words, since the phonological system, which all speakers of the language have in common, automatically recognizes a new, but legal, structure as a word that stands ready to have meaning attached to it. It is only because children have this phonological system that they are able to acquire new words and their meanings with such astonishing ease and rapidity (Studdert-Kennedy 1987).

What follows, then, is that phonology governs all words, whether dead, living, or waiting to be born. So, whatever else a word is, and regardless of whether it is spoken or printed, it is always a phonological structure. If listeners or readers correctly perceive a word, they correctly perceive the structure that distinguishes it. They may very well be unsure of its meaning—indeed, may even have got the meaning wrong—but if they have the phonological structure, they have a perfectly adequate basis for ultimately getting its meaning properly sorted out. As for going directly to meaning—that is, independently of phonology—surely that is done when a person sees a picture, for example, or hears the roar of a lion, but not when one perceives a word as it is spoken or read.

From our point of view, then, there is no reason to ask, as some do, whether readers must, or should get to meaning via the phonology. To make sense of this question, one must make three false assumptions. The first is that the meanings can be communicated in language independently of words (that is, phonological structures), but in fact they cannot. The second is that the phonological units that form all words are equivalent to the sounds of speech, but in fact they are not. And the third is that an alphabetic transcription specifies, on a segment by segment basis, how the speech organs are to be articulated and coarticulated so as to produce the sounds of speech, but in fact it does not. What the reader must do is to match the alphabetic transcription to the abstract phonological structure of the word it represents. In the case of a familiar word, this structure and its associated meaning(s) are available in the reader's lexicon; in the case of an unfamiliar word, given a command of the alpha-

betic principle, the structure is easily formed and thus made ready for whatever meanings may subsequently be attached to it. Once the reader has the phonological form of the word, the appropriate phonetic structure and its associated articulatory movements are automatically available for use in working memory, or for reading aloud if the occasion should call for that.

Phonological Processing in Reading-Writing and in Listening-Speaking

Why is it normally so much harder and less natural to deal with phonological structures in reading and writing than it is in listening and speaking? A serious attempt to answer this question would take us quite deeply into the phonological system and its biology, for the answer requires explaining, among other things, why speech could have evolved in the history of our species but writing systems could not, and why speech can develop in the child without explicit instruction but reading and writing typically cannot (Liberman, in press). Here, we can offer only a truncated account.

Like all members of the animal kingdom, human beings have highly specialized ways of communicating with their fellows. In the human case, and only there, this specialization includes, as a critical component, the phonological system that, as we have seen, makes large vocabularies possible. As this system evolved in the race, and as it develops anew in each child, it employs abstract motor structures—let us call them gestures—that ultimately control the movements of the speech organs (Browman and Goldstein 1985; Liberman and Mattingly 1985; Liberman and Mattingly 1989). These gestures are adapted for one purpose and for one purpose only: the production of strings of consonants and vowels at rates many times more rapid than could otherwise be achieved. These rates, which run about eight to ten per second on average, are managed by precisely overlapping and merging the articulatory movements that produce the phonologically significant aspects of the speech sounds. This

coarticulation, as it is called, is a most complex process, but it does not appear so in the normal exercise of speech functions, because it is done automatically and naturally by this aspect of the specialization for language. A consequence is that a neurologically normal child, put in a speech environment, can hardly be prevented from learning to form phonological structures and to exploit coarticulation for that purpose. (Lacking this specialization, nonhuman primates do not, and cannot, learn to produce these structures; this is to say that they cannot produce words.) A more important consequence for our purposes is that to speak a word one need not know how it is spelled. The speaker need only think of the word; the phonological component of his grammar "spells" it for him. Indeed, the automaticity of this specialization makes it that much harder to be aware of how the word is spelled, or even to know that such a thing as spelling exists.

Perception of the speech signal is correspondingly complex and automatic. Given coarticulation, there is no direct correspondence between the phonological structure intended by the speaker and the surface properties of the sound. Most relevant to our concerns is the fact that, as we have so often pointed out, the number of segments in the sound is not equal to the number of segments in the phonological structure it conveys (Liberman et al. 1967). Thus, the three consonants and vowels of a word like *bag* are so thoroughly coarticulated as to produce a single segment of sound. But this is no problem for listeners, for they have only to rely on their phonological specialization to automatically process the speech signal and recover the coarticulated gestures that caused it (Liberman and Mattingly 1989). It is a problem for would-be readers, however, because, given the complex relation between phonological structure and sound, and the automaticity with which this relation is dealt in speech, they find it just that much harder to be aware that the word does have an internal structure and thus to appreciate why an alphabetic transcription makes sense.

Small wonder then that an alphabetic writing system is such a

comparatively recent development in the history of our species. In contrast to the naturally evolved phonological structures it represents, it is an artifact. The development of this artifact had to wait on the discovery—and it was a discovery—that words have an internal structure. Once that discovery was available, someone could and did invent the notion that, by representing the units of that structure with arbitrarily chosen optical shapes, people could read and write all the words of the language—those they were already familiar with and those they had yet to encounter. But they could exploit this wonderful invention only if they understood the discovery on which it was based.

Awareness of Phonological Structure and Reading

Development of Phonological Awareness in Children

Considerations such as these led us at the very outset of our research on reading to suppose that preliterate children would not naturally have made the discovery that underlay the invention of the alphabet, from which it would follow that they would not be prepared to understand and apply the alphabetic principle. So we began to examine developmental trends in phonological awareness by testing the ability of young children to segment words into their constituent elements. We investigated the children's segmentation of spoken words both by syllable and phoneme (Liberman et al. 1974). (The latter class of units of the phonological representation comprise the consonants and vowels. Heretofore we have referred to these only by the general term *phonological segments*. From now on we will call them *phonemes* to distinguish them from syllables.) We found that normal preschool children performed rather poorly, but that the phonemes presented the greater difficulty by far.

It was clear from these results that awareness of phoneme segments, the basic units of the alphabetic orthography, is initially harder to achieve than awareness of syllable segments, and

develops later, if at all. More relevant to our present purposes, it was also apparent that a large number of children, about 30 percent of our sample, had not attained an understanding of the internal phonemic structure of words, even at the end of a full year in school. Surely, they are the ones we need to worry about, because they are the ones who are deficient in the linguistic awareness that may provide entry into the alphabetic system.

Lack of Phonological Awareness and Reading Failure in Children

Is lack of phonological awareness in fact related to failure in reading and writing? That the answer is yes is strongly supported by studies in a number of languages. In English, the relation has been found, for example, in studies by Blachman (1984), Bradley and Bryant (1983), Fox and Routh (1980), Goldstein (1976), Helfgott (1976), Treiman and Baron (1981) and Vellutino and Scanlon (1987). Their findings have been supported by studies in Swedish by Lundberg and associates (Lundberg, Olofsson and Wall 1980) and Magnusson and Naucler (1987), in Spanish by de Manrique and Gramigna (1984), in French by a group of Belgian researchers (Alegria, Pignot, and Morais 1982), and recently in Italian by Cossu and associates (Cossu et al. 1988).

The study carried out by Lundberg and his associates in Sweden (Lundberg, Olofsson, and Wall 1980) is worthy of special mention on two counts. It provides one of the most intensive examinations of the linguistic abilities of kindergartners. It is noteworthy as well because it also addresses the question of whether the children's deficiency is, in fact, linguistic or whether it might be attributable to a deficiency in general analytic ability. Their battery of eleven tests given to 200 kindergartners included both linguistic and nonlinguistic tasks. In the linguistic set were: (1) word synthesis tasks that varied in two dimensions of two levels each—with or without memory load and using either phoneme or syllable units, and (2) word analysis tasks analogous to

those for synthesis and, in addition, three others demanding analysis of phoneme position in words, reversal of phoneme segments in words, and rhyming. Since the linguistic tasks required the child to shift attention from meaning to abstract form, thus possibly reflecting a general cognitive function not exclusively limited to linguistic material, nonlinguistic control tasks that simulated those cognitive demands were also included. The most powerful predictors of later reading and writing skills in the entire battery turned out to be those requiring phonological awareness, specifically the analytic ability to manipulate phonemes in words. In contrast, the poor readers showed no particular deficiency in the nonlinguistic tasks.

These findings that tasks of linguistic, rather than nonlinguistic analysis, and specifically phonemic analysis, were predictive of reading failure have since received support from other studies here and abroad. For example, in a study of six to nine year olds with severe reading disability (Morais, Cluytens, and Alegria 1984) it was found that these children were poorer on segmenting words into their constituent parts but performed just as well as normal readers in a matched task that required them to deal analytically with musical tone sequences instead of words. The question of a possible general analytic deficit was also addressed in two complementary experiments, one with good and poor readers in the third grade and the other with good and poor readers in adult education classes (Pratt 1985). All the subjects were given three linguistic awareness tests and one nonspeech control task identical in format to one of the linguistic measures. Significant differences were found between the good and poor readers at both age levels on all three linguistic measures, but not on the nonspeech control task. Thus the poor readers, whether young or old, had no more difficulty in segmental analysis than the good readers when the task was nonlinguistic; their problem was limited to the segmental analysis of speech.

Not only reading, but early spelling proficiency has also been found to be closely related to analytic phonological skills. In a study of kindergartners (Liberman et al. 1985), the children's

ability to produce invented spellings, given only some knowledge of letter names (see Read 1986), was related to their performance on a series of language-based tasks. It was found that the children's proficiency in spelling was more closely tied to phonological awareness than to any of the other aspects of language development tested. Of the eight tasks in the study, only the three that unquestionably tapped phonological analysis skills made a difference statistically. They combined to account for 93 percent of the variance in proficiency in invented spelling. A phoneme analysis test patterned after Lundberg, Olofsson, and Wall (1980) made the largest contribution—67 percent of the variance. A test of the ability to write letters to phoneme dictation accounted for 20 percent more, and a phoneme deletion task ("Say *milk* without the *m*") added another 6 percent. (A fourth task, picture naming, added 1 percent, but did not reach significance in the correlation. As we will note later, however, naming can be a subtle indicator of more general phonological difficulties.)

Among the four language-based tests that did not contribute to the invented spelling performance were three that are frequently included in clinical evaluations: receptive vocabulary, articulation as measured by the repetition of simple words, and letter naming or writing. The fourth was a syllable deletion test ("Say *bookcase* without the *book*"). Being able to segment words by syllable was, as we would expect, not enough to equip the child to produce alphabetically written words.

The Remedial Effect of Training in Awareness

Given the abundant evidence that phonological awareness is predictive of success in reading, it is of interest to know that such awareness can be trained even in preschool and kindergarten (Bradley and Bryant 1983; Content et al. 1982; Lundberg, Frost, and Petersen 1988; Olofsson and Lundberg 1983). It is of special interest to find, moreover, that the training can have a salutary effect on future reading skill. Impressive evidence for the efficacy of the training comes from a pair of experiments by

Bradley and Bryant (1983). The first experiment confirmed the high correlations found by others between preschoolers' phonological awareness and later reading skill. This was done by a comparison of children's performance on rhyming tasks and their achievement in reading and spelling several years later. The second experiment was directed to an examination of the effect of various kinds of early training on the later academic achievements of children considered to be at risk for failure. To this end, the children who had been found in the first experiment to have a low level of phonological awareness were divided into four groups. One group was trained to sort pictured words on cards by phonological categories. A second received the same training except that letters corresponding to the phonemic categories were added. A third group was trained to sort by semantic categories. A control group was given equal time and unrelated card play. The two phonologically trained groups were found to be superior to the others in subsequent tests of reading and spelling. Moreover, in follow-up studies, they continued to maintain their advantage.

Further evidence for the positive effect of early training in phonological awareness is found in the longitudinal study by Lundberg and associates (Lundberg, Frost, and Petersen 1988). An experimental group of kindergartners who had participated in a variety of analytic word games was found at year-end to be superior in phoneme awareness to a matched control group. When compared in academic achievement in the first grade, the experimental group was slightly below the controls in math and IQ but significantly superior in both reading and spelling. Moreover their advantage was maintained when the children were retested in the second grade.

Lack of Phonological Awareness and Adult Literacy

What about phonological awareness in adult nonreaders? Is it still a problem for them? The question as to whether phonologi-

cal awareness improves spontaneously with age or requires some form of instruction is a crucial one, with obvious implications not only for preschool instruction but also for the design of literacy teaching programs geared to adolescents and adults. This question was explored in an unusual investigation by a Belgian research group who examined the phonological awareness of illiterate adults in a rural area of Portugal (Morais et al. 1979). They found that the illiterate adults could neither delete nor add phonemes at the beginning of nonsense words, whereas others from the same community who had received reading instruction in an adult literacy class succeeded in performing those tasks. The authors concluded that awareness of phoneme segmentation does not develop spontaneously even by adulthood but arises as a concomitant of reading instruction and experience.

In view of these findings, we believed it would prove of value to test the phonological awareness of adults who had had reading instruction but were nonetheless poor readers. To this end, our reading research group (Liberman et al. 1985) tested the members of a community literacy class, all of whom were having serious decoding problems despite years of schooling. What we found was that these adults performed with difficulty on a very simple task in which the subjects were required only to identify the initial, medial, or final sound in monosyllabic words. Though this is an exercise that one might expect a first grader to be able to perform, our adults managed to produce correct responses on only 58 percent of the items. Moreover, they clearly found it to be singularly frustrating and unpleasant. This inability of adults with literacy problems to perform well on tasks demanding explicit understanding of phonological structure has also been found by other investigators—Byrne and Ledez (1983) in Australia, Marcel (1980) in England, and Read and Ruyter (1985) in a prison population in the United States.

A Broader Phonological Deficiency and Reading

Why do some people have difficulty in achieving the understanding of phonological structure that application of the alphabetic

principle requires? One possibility, as we noted before, is that they may suffer from a general deficiency in the ability to divide objects of all kinds into their constituent elements. But as we pointed out, the results of several studies suggest that the difficulty is specifically linguistic. Another possibility—one that we and others have pursued—is that the poor reader's difficulty with analyzing words into their constituent units is one among several symptoms of a general deficiency in the phonological component of the child's natural capacity for language. If the underlying biology tends to set up phonological structures weakly, then it should follow that these structures would be that much harder for the child to bring to a level of explicit awareness. But there would be other consequences for the processing of language, and these we consider below.

Problems in Short-Term Memory and Sentence Comprehension

Because short-term memory depends on the ability to gain access to phonological structure and to use it to hold linguistic information (Conrad 1964; Liberman, Mattingly, and Turvey 1972), we might expect people who have underlying phonological deficiencies to show various limitations on verbal tasks that tap short-term memory. This expectation is amply borne out.

The research literature contains many reports that young children who are poor readers are deficient in short-term memory. Typically they retain fewer items from a set of fixed size than age-matched good readers (see Mann, Liberman, and Shankweiler 1980; Shankweiler et al. 1985; Shankweiler, Smith, and Mann 1984; Wagner and Torgesen 1987). However, memory difficulties for poor readers appear to arise only under specific conditions; chiefly, they occur when the items to be retained are words and nameable objects. When the test materials do not lend themselves to verbal (i.e., phonological) encoding, as in memory for nonsense shapes or unfamiliar faces, memory testing does not find poor readers at a disadvantage (Katz, Shank-

weiler, and Liberman 1981; Liberman et al. 1982). The problem seems, therefore, to be a material-specific one, not an all-embracing memory impairment.

It is noteworthy, in addition, that memory differences between good and poor readers may also depend on other demands of the task—tasks that require rote recall of a list of unstructured items may be less differentiating than tasks that require both storage and further processing of the incoming material as in sentence processing (Daneman and Carpenter 1980; Perfetti and Goldman 1976). Since language structures are hierarchically organized and sequentially transmitted, comprehension of language, either by ear or by eye, depends on a short-term memory system that transiently stores and continuously processes the incoming segments of the linguistic message. In keeping with current usage (see Baddeley and Hitch 1974; also Shankweiler and Crain 1986), we call this form of memory *working memory*, a term which is used throughout this book. A phonological deficiency would understandably impair the functions of working memory and could be expected, in turn, to have repercussions on comprehension, whether of spoken discourse or printed text. For example, in sentence processing, the parsing of phonological segments into lexical units and the groupings of these units into higher-level phrasal structures requires phased control of the flow of linguistic information through the language apparatus.

We could therefore expect that children with reading disability would sometimes comprehend sentences poorly because of their difficulties in setting up and retaining phonological structures. The difficulty should be especially acute in reading, where the problem of decoding from print would create an additional processing load in an unskilled reader who decodes poorly. The important insight that the lower-level and higher-level reading problems of the poor reader are causally connected through constriction of working memory was contributed by Perfetti and Lesgold (1979). In their terms, poor decoding skills coupled with the limitations of working memory create in the poor reader a

"bottleneck" in information flow with severe repercussions for comprehension.

But, as Crain and Shankweiler will discuss in later chapters of this volume, comprehension difficulties of poor readers are not limited to reading. From our working memory perspective, difficulties should also arise in spoken language processing, especially if the sentence material contains remote dependencies or structural ambiguities that necessitate reanalysis, or if the comprehension task presents additional complexities that further dilute memory resources. Several reports in the literature indicate that disabled readers do have problems in comprehending such sentences in spoken form as well as in reading (Byrne 1981; Mann, Shankweiler, and Smith 1984; Stein, Cairns, and Zurif 1984). More recent findings (which will be discussed in later chapters) indicate that the poor readers fail not because they lag behind their good reading peers in comprehension of grammar as such, but because working memory is overloaded due to deficient phonological processing.

By changing the task in various ways to reduce the demands on memory while testing the same grammatical structures, it has been shown that poor readers can succeed as well as good readers in comprehending complex grammatical structures (Crain et al., forthcoming; Smith et al., forthcoming). Thus, a memory impairment stemming from a weakness in phonological processing can masquerade as a grammatical or semantic deficit.

Other Language-Related Problems

Thus far we have discussed difficulties involving the phonological components of language that directly affect reading. Reading is affected both by the difficulties of accessing and mentally manipulating phonemic segments and by the limitations on use of the working memory that we have just discussed (though in the case of working memory the consequences are not confined to reading). We now turn to other deficits displayed by poor readers that are phonological in nature, but do not affect

reading directly. These are worth mentioning, both for their diagnostic value, and because they add to the weight of the evidence that all the elements of the syndrome of many poor readers may stem ultimately from a deficiency in phonological processing.

One such deficit is suggested by some preliminary research into the speech perception of poor readers that was carried out by Brady and associates at Haskins Laboratories (Brady, Shankweiler, and Mann 1983). In their experiments, good and poor readers were tested on two auditory perception tasks, one involving words and the other nonspeech environmental sounds. The identification tasks were presented under two conditions—with favorable and unfavorable noise ratios. The findings were that the poor readers did show a deficit, but it was specific to the speech stimuli and occurred only in the noise-masked condition. They did not differ from the good readers in the perception of nonspeech environmental sounds, whether the sounds were noise-masked or not. Note that the poor readers apparently needed a higher quality of signal than the good readers for error-free performance in speech, but not for nonspeech environmental sounds. These results suggest that the minor deficit displayed by the poor readers may derive from phonological structures that are set up more weakly than in good readers, or are more difficult to activate.

Additional evidence for a broader phonological deficit in poor readers is provided by a study of speech production, specifically, the errors of junior high school students (Catts 1986). The critical finding was that the reading-disabled students made significantly more errors than matched normals on three different tasks in which their speech production was stressed. The author concluded, as we would, that their difficulties in speech production may be an extension of deficits in the phonological realm.

More evidence for a broad phonological deficit in poor readers was provided by a study of the performance of second graders on a naming test (Katz 1986). This study confirmed what

others had shown—that poor readers named more words incorrectly. But it went further to show that their difficulties are often phonological and not semantic, as might be assumed. Three kinds of evidence were presented in this regard. First, when quizzed about the characteristics of the object they had named incorrectly (e.g., "tornado" for volcano), the poor readers were often able to describe it accurately. They clearly knew what the object was. That is, they described a volcano, not a tornado. Second, given the name of the item, they could select it from a group of pictured objects. That is, they could identify it correctly. And third, their naming errors were often related to the phonological and not the semantic aspect of the word. For example, though the name given to the picture of a volcano was incorrect, it shared syllable count, stress pattern, and vowels with the target word.

Distorted production of the word for an item that had been correctly identified could stem either from deficient specification of the phonological structure in the lexicon, or from deficient retrieval and processing of the stored phonological information. In either case, the source of the difficulty relates to the phonological structure of the words and not to their meanings.

Phonology and the Successful Deaf Reader

The congenitally deaf constitute a population with a phonological impairment arising from an entirely different source. Surprisingly, this group represents some of the most compelling evidence for the importance of phonological abilities for reading. It is well known that profound deafness from birth or early life usually results in attainment of a low level of reading skill. The hearing impaired of all ages tend to read far below grade expectations. But, nonetheless, differences in reading achievement are related to differences in phonological abilities even in deaf populations. Moreover, a few congenitally, profoundly deaf individuals can read well, even up to the college level.

How are these successful deaf readers different from the ma-

jority? Vicki Hanson and her associates at Haskins Laboratories asked that question in a series of experiments (Hanson 1982; Hanson and Fowler 1987; Hanson, Liberman, and Shankweiler 1984), which she will report on in detail in chapter 3. Briefly, they found that the successful deaf readers were not limited to reading English words as if they were logographs; that is, they were not, as one might assume, dependent on a limited store of words learned in paired associate fashion as visual designs. The results, which are discussed in detail in the chapter by Hanson, showed that unlike their poor reading peers among the deaf, these subjects, despite so little exposure to sound, were able to access phonological knowledge both in reading and in retaining verbal material in short-term memory.

In reading, the good readers among the deaf displayed their phonological sensitivity by responding differentially to rhyming and nonrhyming pairs of words (*save/wave* vs. *have/cave*) and by being able to name the real word equivalents of nonwords (*flame* for f-l-a-i-m; *tall* for t-a-u-l). In a short-term memory experiment, the successful deaf readers were more affected by phonetically confusing words than by those that were orthographically confusing or whose signs were formationally confusing. These results certainly suggest that successful deaf readers are using phonological processing, a conclusion also reached by Conrad with a less severely impaired population of deaf readers (Conrad 1979).

The question of how the congenitally, profoundly deaf might develop phonological sensitivity without being able to hear the sounds of speech is explored by Hanson (in this volume). She identifies several sources of information that may be helpful. The orthography itself tells them something about the systematic phonological forms of words. In addition, oral training when available supplies information about the gestures used to produce speech. Lipreading also provides considerable useable information, and the deaf individual's own attempts at speech may reflect more phonological sensitivity than is apparent to the hearing listener.

Implications for Instruction

In view of all the evidence that has accumulated in the past fifteen years to support the critical importance of phonological sensitivity for the attainment of literacy in an alphabetic system, one would surely expect teacher training to reflect these findings. Unfortunately, all too often it does not. Many teachers are being trained to teach reading without themselves ever having learned how an alphabetic orthography represents the language, why it is important for beginners to understand how the internal phonological structure of words relates to the orthography, or why it is hard for children to achieve this understanding.

In fact, teachers are all too often being provided with an instructional procedure that directs them specifically not to trouble the learner with details of how the alphabet works. Instead, they are told to view reading as a "guessing game" (Goodman 1976) in which the general import of the message, and not the actual words of the text, is to be emphasized. Beginners are encouraged to memorize the appearance of words as visual patterns by whatever means they can muster and to use their store of memorized words and their "whole language" capability as a basis for guessing the rest of the message from picture cues and context. Thus, they are not to be corrected when reading "kids" for *children* in a story about a playground, "Crest" for *toothpaste* in a story about dental hygiene, and "cats" for *dogs* in a story about pets.

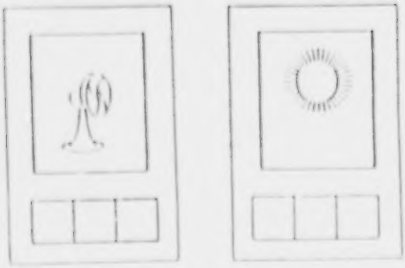
Fortunately, many children—the lucky 75 percent or so who learn to read whatever the method—manage to pick up the alphabetic principle without much explicit instruction, if any. That is, given experience with printed material, they begin to discover for themselves the commonalities between similarly spoken and written words. When tested in kindergarten, these children turn out to be the ones with strengths in the phonological domain. For the large group of children with phonological deficiencies who do not understand that the spoken word has segments, and who have not discovered on their own that there

is a correspondence between those segments and the segments of the printed word, the current vogue for the so-called (and from our point of view, misnamed) psycholinguistic guessing game and its offshoots, the "whole language" and "language experience" approaches, are likely to be disastrous. Many children taught this way are likely to join the ranks of the millions of functional illiterates in our country who stumble along, guessing at the printed message from their inadequate store of memorized words, unable to decipher a new word they have never seen before.

For those beginners who do not discover the alphabetic principle unaided, an introductory method that provides them with direct instruction in what they need to know is critical (Liberman 1985; Liberman and Shankweiler 1979). Direct instruction could begin with language analysis activities that are incorporated into the daily reading lesson. These activities can take many different forms, limited in number and variety only by the creativity of the teacher. The Auditory Discrimination in Depth Program of Lindamood and Lindamood (1975) is an ingenious method for helping the student to apprehend the internal phonological structure of words. It does this by calling the student's attention to the perceived distinctiveness of the articulatory gestures for the various phonemic constituents of spoken words and then demonstrating their sequences in syllables with variously colored blocks. The method was originally developed for individual reading remediation, but is currently being adapted for classroom use.

Adaptations of three exercises that we advocated some years ago (Liberman et al. 1980) have recently been shown by one of our colleagues (Blachman 1987) to be effective in improving reading skills even in an inner city school with a high incidence of reading failure. They are outlined in figure 1. In the first procedure, one originally devised by the Soviet educator Elkonin (1973), Blachman presents the child with a simple line drawing representing the word to be analyzed. A rectangle under the drawing is divided into squares equal in number to the phonemes

ELKONIN (1973)



ENGELMANN (1969)

SLINGERLAND (1971)

Fig. 1. Language analysis activities. (After Blachman 1987 and Liberman et al. 1980.)

in the picture word. The children are taught to say the word slowly, placing a counter in the appropriate squares of the diagram as the word is being slowly articulated. The words selected must begin with a fricative, liquid, or nasal rather than a stop consonant in order to permit their component phonemes to be accessed readily. Later, as the child progresses, the counters are color-coded—one color for vowels, another for consonants. Letter symbols can be added as well. In another activity, this one

adapted from Engelmann (1969), the children are taught how to read as a single unit the combination of a consonant followed by a vowel. For example, the teacher writes a consonant on the blackboard (preferably, a fricative, nasal, or liquid)—the letter *s*, for example—and produces it, holding it over time until she writes the vowel and pronounces that. The length of time between the pronunciations of the initial consonant and the vowel (as well as a line drawn between them on the board) is then reduced step by step until the two phonemes are pronounced as a single unit—"sa". By adding stop consonants in the final position and pronouncing the resultant words, the children can begin to accumulate a pool of real words (sag, sat, sad, etc.). Thereafter, new vowels and new consonants can be introduced in the same way, and built into new words that are incorporated into stories to be read and written.

A similar effect can be produced by a third procedure, adapted from Slingerland (1971), in which a small pocket chart is used by the child at each desk to manipulate individual letters to form new words and learn new phonemes. The words thus constructed, along with a few nonphonetic "sight" words, can be used in stories and poems to be read and written by the child. Note that the child is now reading and writing words the structure of which is no longer a mystery and the understanding of which can be used productively to form related words (bag, bat, bad, big, bit, bid, etc.).

All these language analysis activities and others like them can be played as games in which the introduction of each new element not only informs but delights. Beginning readers with adequate phonological ability will require only a relatively brief exposure to such activities. They will soon develop skills that will enable them to decode the new words of the text and to go from them to the meaning of the passage. For such readers, language analysis can be quickly followed, or even accompanied, by practice with interesting reading materials from other sources. These children will benefit from the added skill that comes from increased reading practice and the further enhance-

ment of vocabulary and knowledge that comes with expanded reading and life experience. But unless they receive extra assistance, the many beginners with weakness in phonological skills, who may include as many as 20 to 25 percent of the children, will remain locked into a sight-word stage of reading, able to cope only with those few words they have already memorized. They will not learn to decode new words—the essence of true reading skill—unless the method initially includes more intensive, direct, and systematic training in phonological structure and demonstrates how it relates to the way words are written. Research support for this view has been available for at least twenty years (see Chall 1967 or Pflaum et al. 1980). It is surely time to put the research into practice.

NOTE

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